The Human Body in Health and Disease

Fourth Edition

Memmler, Wood,

in Health and Disease

Fourth Edition

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Preface

As was true of previous editions, the primary aim of the authors in preparing the fourth edition is to introduce the student to principles of the biological and the physical sciences that contribute to an understanding of normal body processes and of abnormal states and conditions. The sciences of anatomy, physiology and pathology are emphasized, because they are basic to the student's understanding; elements of microbiology, chemistry and physics also are included. Thus, this edition is a more completely integrated science text than was any earlier one.

The text has been extensively updated to include current information at both the *conceptual* level and the *clinical* level. In the former category, the topics of DNA, acid-base balance, atomic structure, microorganisms, amino acids, metabolism, blood coagulation, Fahrenheit and Celsius scales, pH, the metric system, levers and body mechanics, physiology of respiration, and hormonal activity have been thoroughly revised or are new. In the latter category, the topics of blood studies (including SMA), sickle cell anemia, cancer, erythroblastosis fetalis, gamma globulin, sclerotic diseases, diet, cataract removal, diabetes mellitus, emphysema, tuberculosis, dialysis, "the pill," arterial replacement and immune serums are new or have been heavily revised. A completely new chapter, "Heredity and Hereditary Diseases," was written in response to current student interest in the factors that govern genetic endowment. It takes the student from general principles of inheritance through prevalent and widely known hereditary diseases.

The pronunciation key, which affords the inexperienced student a time-saving guide to medical terms, has been retained, with every keyed word set off in boldface type for instant recognition. To further assist the student in gaining understanding of medical terms, the glossary has been completely overhauled: obsolete or recondite words have been deleted and up-to-date terms have been entered.

Both instructor and student should find the new illustrations, which were prepared by the outstanding anatomical artist, Anthony Ravielli, beautiful to look at and interesting to study. We are sure they will prove to be a valuable addition to the book. They supplement and enrich the text, often "telling the story" better than words could do.

The order in which chapters are assigned for study should depend upon the particular curriculum and classroom needs. It is not incumbent upon the

instructor to follow the arrangement presented here. For example, we are acquainted with instructors who prefer to begin with the chapter titled, "Digestion and Indigestion," because of the importance of diet and of the health worker's role in discussing nutrition with patients; other instructors prefer to begin with the chapter titled, "The Brain, the Spinal Cord and the Nerves," because the nervous system controls the all-important processes of circulation and respiration. We believe this flexibility is desirable in an introductory textbook.

To enhance the student's ability to apply his newly acquired knowledge of anatomy and physiology, an accompanying workbook is available. The workbook is closely correlated with the textbook, and affords numerous opportunities for self-testing.

We thank the many readers who have taken the time to suggest changes and improvements for this edition. Particularly do we thank Edmond Stout, Associate Professor, Department of Education, and Lecturer in Biology, St. Joseph's College, Philadelphia, who painstakingly reviewed the entire manuscript and made valuable suggestions throughout, especially as regards Chapter 3, "Chemistry, Matter and Life." We express our indebtedness to the staff of the J. B. Lippincott Company, particularly Bernice Heller, Editor, Nursing and Allied Health Sciences, and David T. Miller, Managing Editor, Nursing Department.

Ruth L. Memmler
Dena L. Wood

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CHAPTER ONE

Living matter and cells •
Microscopes •
Organs and organ-systems •
Directions and locations in the body •
Dorsal and ventral body cavities •
The metric system •

The General Plan of the Human Body

What Are Living Things Made Of?

According to a nursery rhyme children are made of sugar and spice, or perhaps of puppy dogs' tails, depending on which sex we are discussing. More accurately, the "stuff" of which all living things are made is called **protoplasm** (pro'to-plazm). This word is made up of 2 Greek words: *proto*, meaning "original," and *plasm*, meaning "substance." Chemically, protoplasm is composed of quite ordinary elements, such as carbon, oxygen, hydrogen, sulfur, nitrogen and phosphorus. There is nothing extraordinary, either, in the appearance of protoplasm; it looks very much like the white of an egg. Yet, nobody has been able to explain why protoplasm has that characteristic which we call life. We will learn more about this intricate substance in Chapter 3.

If the building material of all living things, both plants and animals, is protoplasm, the building blocks made of this are called **cells** (see Fig. 1.1). Cells vary a great deal in size. Something as small as a worm may be composed of millions of cells, yet we all are familiar with at least one of the larger kinds of cells, of which an egg is a perfectly good example. In fact, if we keep the egg in mind, the construction of the cell will be quite easy to visualize. Let us work our way from the outside to the center.

First comes the outer covering, called the **cell membrane**. Next is the main substance of the cell, the **cytoplasm** (si'to-plazm), which might be likened to the white of the egg. The cytoplasm contains water, food particles, pigment and other specialized materials. In the center of the cell, comparable with the egg yolk, is a globule called the **nucleus** (nu'kle-us), containing the chromatin network. The nucleus controls some of the activities of the cell, including its reproduction. Within the nucleus is still another tiny globule of matter called the **nucleolus** (nu-kle'o-lus), the function of which is related to reproduction. The unique ability of a cell to reproduce itself will be discussed in Chapter 4.

The scientific study of cells began with the invention by Antony van Leeuwenhoek of the microscope some 350 years ago. In time his single lens microscope was replaced by the modern compound microscope which has two sets of lenses. This is the type in use in most laboratories. In recent years a great boon to microbiologists has been the development of the electron microscope, which

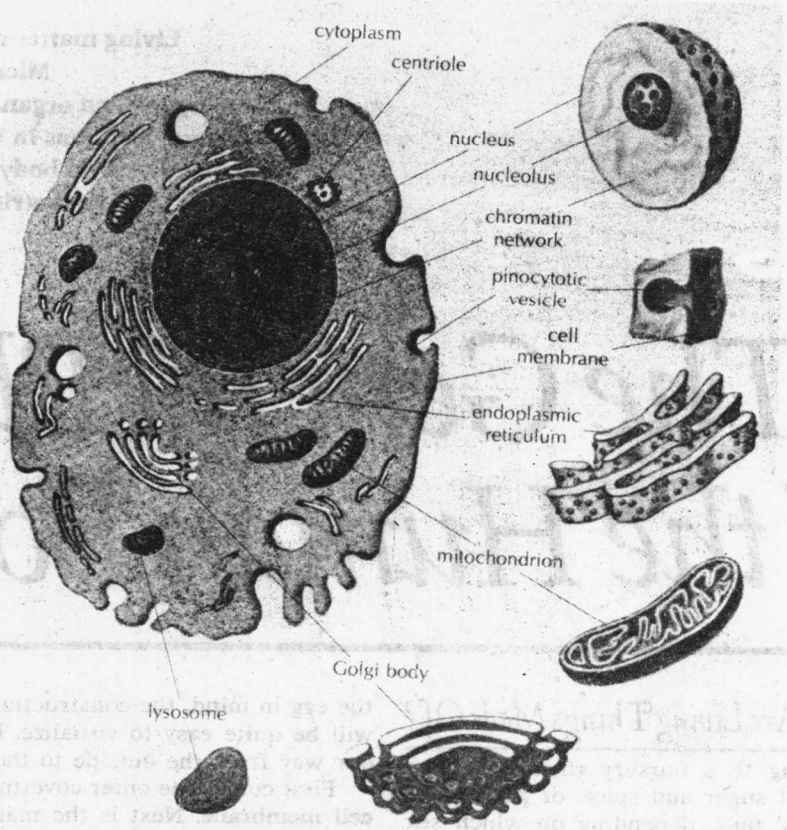

Figure 1.1. A typical cell. The nucleus is the control center. The organelles—the endoplasmic reticulum, the mitochondrion, the Golgi body, and the lysosomes—are the functional substances.

by a combination of magnification and enlargement of the resulting image affords magnification to one million times or more (Fig. 1.2).

The cell, then, is the basic unit of all life. When you study the causes of disease, you will encounter a number of primitive living things which are composed of but one cell. However, for the moment we shall confine our discussion to the human body, which is made up of many millions of cells. The body is composed of specialized groups of cells, the first of which are called **tissues.** Various tissues that together perform a single function form **organs,** and several organs and parts grouped together for certain functions form **systems.** The heart is an organ composed of muscle tissue, connective tissue and nerve tissue, all working together to pump blood. The heart and the blood vessels comprise the circulatory system.

Body Systems

The body systems have been variously stated to be nine, ten or eleven in number, depending on how much detail one wishes to include.

Here is one list of systems:

1. The **skeletal system.** The basic framework of the body is a system of over 200 bones with their joints, collectively known as the skeleton.
2. The **muscular system.** Body movements are due to the action of the muscles which are attached to the bones. Other types of muscles are

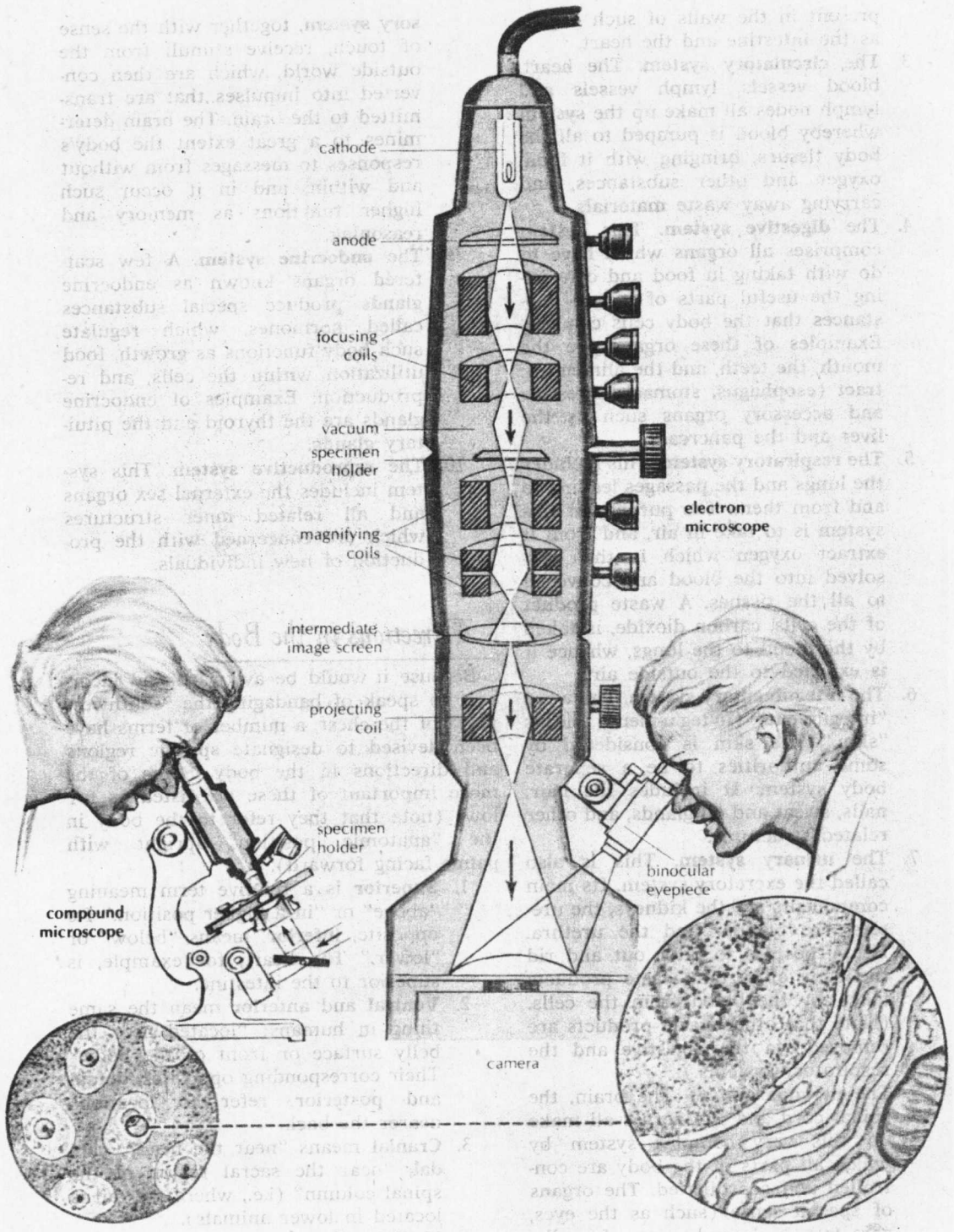

Figure 1.2. A simplified comparison of an optical microscope and an electron microscope.

present in the walls of such organs as the intestine and the heart.

3. The **circulatory system.** The heart, blood vessels, lymph vessels and lymph nodes all make up the system whereby blood is pumped to all the body tissues, bringing with it food, oxygen and other substances, and carrying away waste materials.
4. The **digestive system.** This system comprises all organs which have to do with taking in food and converting the useful parts of it into substances that the body cells can use. Examples of these organs are the mouth, the teeth, and the alimentary tract (esophagus, stomach, intestine and accessory organs such as the liver and the pancreas).
5. The **respiratory system.** This includes the lungs and the passages leading to and from them. The purpose of this system is to take in air, and from it extract oxygen which is then dissolved into the blood and conveyed to all the tissues. A waste product of the cells, carbon dioxide, is taken by the blood to the lungs, whence it is expelled to the outside air.
6. The **integumentary system.** The word "integument" (in-teg'u-ment) means "skin." The skin is considered by some authorities to be a separate body system. It includes the hair, nails, sweat and oil glands, and other related structures.
7. The **urinary system.** This is also called the excretory system. Its main components are the kidneys, the ureters, the bladder and the urethra. Its purpose is to filter out and rid the body of certain waste products taken by the blood from the cells. (Note that other waste products are removed via the digestive and the respiratory systems.)
8. The **nervous system.** The brain, the spinal cord and the nerves all make up this very complex system by which all parts of the body are controlled and coordinated. The organs of special sense (such as the eyes, ears, taste buds, and organs of smell), sometimes classed as a separate **sensory system**, together with the sense of touch, receive stimuli from the outside world, which are then converted into impulses that are transmitted to the brain. The brain determines to a great extent the body's responses to messages from without and within, and in it occur such higher functions as memory and reasoning.
9. The **endocrine system.** A few scattered organs known as endocrine glands produce special substances called hormones, which regulate such body functions as growth, food utilization within the cells, and reproduction. Examples of endocrine glands are the thyroid and the pituitary glands.
10. The **reproductive system.** This system includes the external sex organs and all related inner structures which are concerned with the production of new individuals.

Directions in the Body

Because it would be awkward and incorrect to speak of bandaging the "southwest part" of the chest, a number of terms have been devised to designate specific regions and directions in the body. Some of the more important of these are listed as follows (note that they refer to the body in the "anatomic position"—upright with palms facing forward):

1. **Superior** is a relative term meaning "above" or "in a higher position." Its opposite, **inferior**, means "below" or "lower." The heart, for example, is superior to the intestine.
2. **Ventral** and **anterior** mean the same thing in humans: "located near the belly surface or front of the body." Their corresponding opposites, **dorsal** and **posterior**, refer to locations nearer the back.
3. **Cranial** means "near the head"; **caudal**, "near the sacral region of the spinal column" (i.e., where the tail is located in lower animals).
4. **Medial** means "near an imaginary plane that passes through the midline

of the **body**, dividing it into left and right **portions**." **Lateral**, its opposite, **means** "farther away from the midline," toward the side.

5. **Proximal** means "nearest the origin of a structure"; **distal**, "farthest from that point." For example, the part of your thumb where it joins your hand is its proximal region. The tip of the thumb is its distal region.

For convenience in visualizing the spatial relationships of various body structures to each other, anatomists have divided the body by means of three imaginary planes. Think of a body plane as a huge cleaver (see Fig. 1.3).

1. The **midsagittal** (mid-saj'i-tal) **plane.** If the cleaver were to cut the body in two down the middle in a fore-and-aft direction, separating it into right and left portions, the sections you would see would be midsagittal.
2. The **frontal plane**. If, instead of the above operation, the cleaver were held in line with the ears and then were brought down the middle of the body, creating a front and a rear portion, you would see a front (anterior or ventral) section and a rear (posterior or dorsal) section.
3. The **transverse plane**. If the cleaver blade were swung horizontally, it would divide the body into an upper (superior) part and a lower (inferior) portion. There could be many such cross sections, each of which is on a transverse plane.

Body Cavities

The body contains a few large internal spaces or cavities within which various organs are located. There are two groups of cavities: **dorsal** and **ventral** (see Fig. 1.4).

Dorsal Cavities

There are two dorsal cavities: (1) the **cranial cavity**, containing the brain; and (2) the **spinal cavity**, enclosing the spinal cord. Both of these cavities join, hence they are a continuous space.

Ventral Cavities

The ventral cavities are much larger than the dorsal ones. There are two ventral cavities: (1) the **thoracic cavity**, containing mainly the heart, the lungs and the large blood vessels, and (2) the **abdominal cavity**. This latter space is subdivided into two portions, one containing the stomach, most of the intestine, the kidneys, the liver, the gallbladder, the pancreas and the spleen; and a lower one called the **pelvis**, or pelvic cavity, in which are located the urinary bladder, the rectum and the internal parts of the reproductive system.

Unlike the dorsal cavities, the ventral cavities are not continuous. They are separated by a muscular partition, the **diaphragm** (di'ah-fram), the function of which is discussed in Chapter 16.

Regions in the abdominal cavity

Because the abdominal cavity is so large, it has been found helpful to divide it into nine regions. These are shown in Fig. 1.5. The three central regions are the **epigastrium** (ep-i-gas'tre-um), located just below the breastbone; the **umbilical** (um-bil'i-kal) **region** about the umbilicus (um-bil'i-kus), commonly called the navel; and the **hypogastric** (hi-po-gas'trik) **region**, the lowest of all of the midline regions. At each side are the right and left **hypochondriac** (hi-po-kon'dre-ak) regions, just below the ribs; then the right and left **lumbar** regions; and finally, the right and left **iliac**, or **inguinal** (in'gwi-nal), regions. A much simpler division into four quadrants (right upper, left upper, right lower, left lower) is now less frequently used.

The Metric System

Now that we have set the stage for further study of the body, its structure and its processes, a look at the metric system would be in order since it is rapidly replacing the present system of measurement in the United States. The drug industry and the health care industry already have converted to the metric system, so anyone who plans a career in health should be acquainted with metrics.

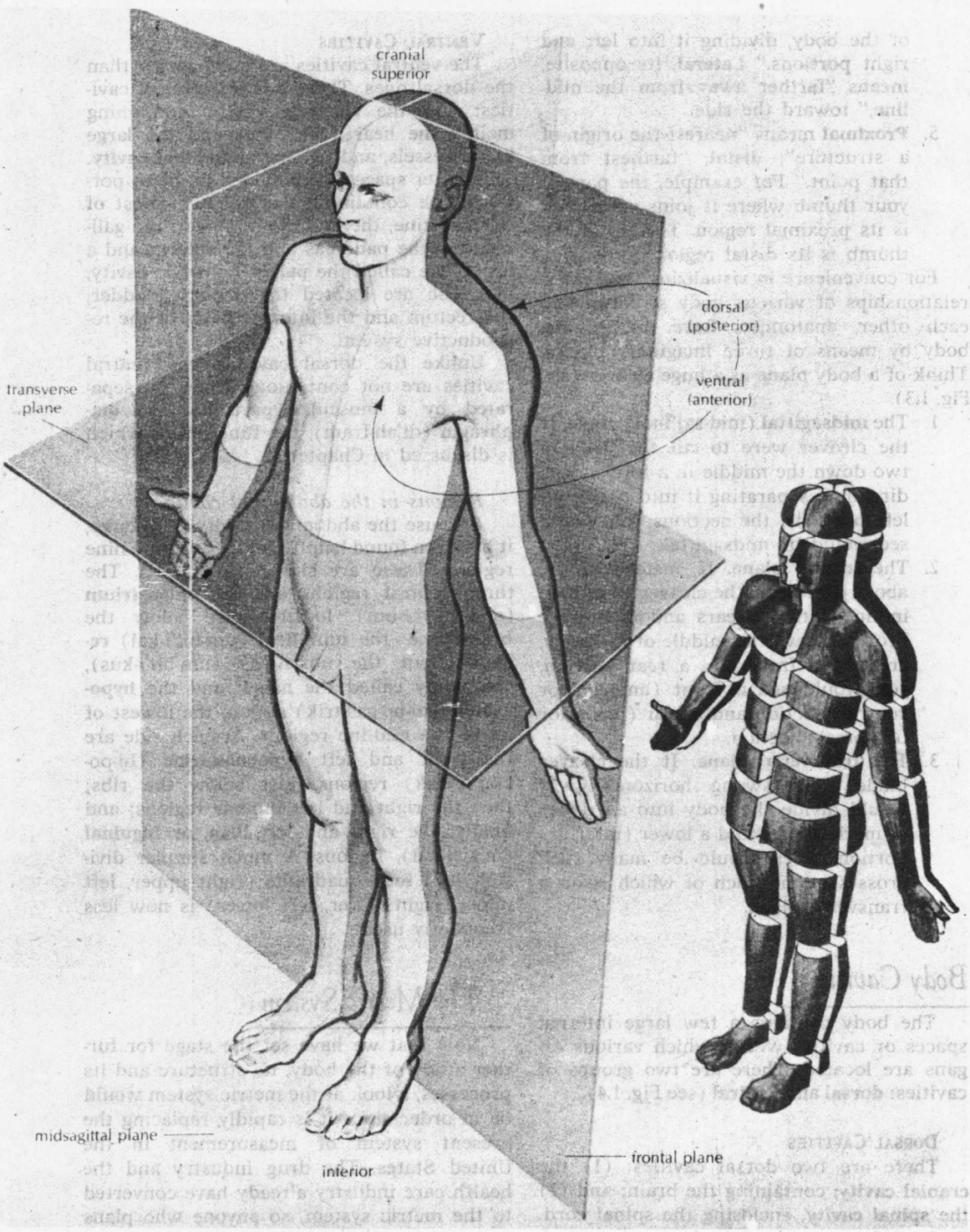

Figure 1.3. Body planes and directions.

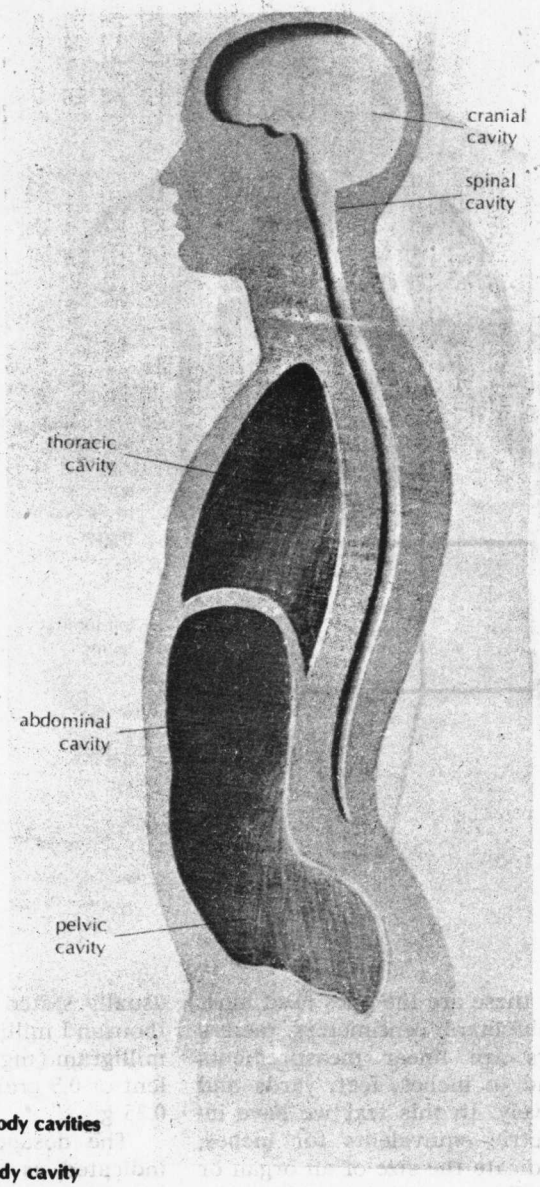

Figure 1.4. Side view of body cavities.

To use the metric system easily and correctly may require a bit of effort as is often the case with any new idea. Actually, you already know something about the metric system, because our monetary system is similar to it in that both are decimal systems. One hundred cents equals one dollar, 100 centimeters equals 1 meter. The first step is to learn the meanings of the following prefixes:

centi (1/100): 100 centimeters (cm.) = 1 meter (m.)

milli (1/1000): 1,000 millimeters (mm.) = 1 meter (m.)

kilo (1,000): 1,000 meters = a kilometer (km.) (kil'o-me-ter)

The metric system includes other mea-

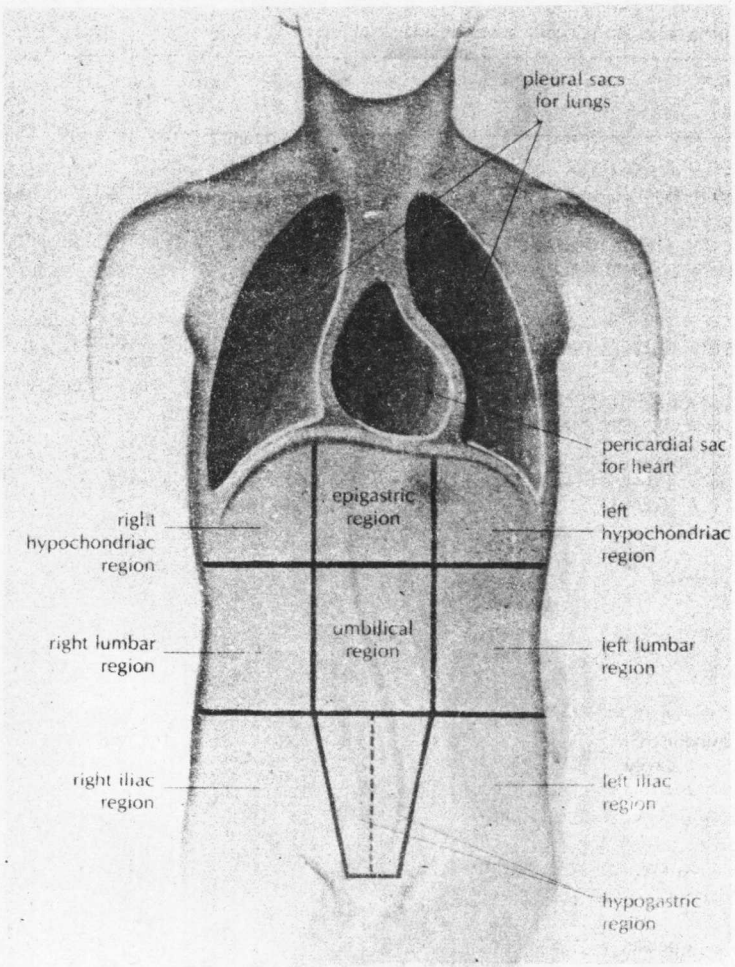

Figure 1.5. Front view of body cavities and the regions of the abdomen.

surements, but these are the ones used most frequently. Millimeters, centimeters, meters and kilometers are linear measurements that correspond to inches, feet, yards and miles, respectively. In this text we have included the metric equivalents for inches, feet, etc., to indicate the size of an organ or part (Fig. 1.6). Some equivalents that may help you to appreciate the size of various body parts are:

1 mm. = 0.04 in., or 1 in. = 25 mm.
1 cm. = 0.4 in., or 1 in. = 2.5 cm.
1 m. = 3.3 ft., or 1 ft. = 30 cm.

The same prefixes are used as for the linear measurements. The meter is the standard for length, the gram for weights. Thirty grams is approximately equal to 1 ounce and 1 kilogram to 2.2 pounds. Drug dosages are usually stated in grams or milligrams. One thousand milligrams equals one gram; a 500 milligram (mg.) dosage would be the equivalent of 0.5 gram (g.) and 250 mg. is equal to 0.25 g.

The dosages of liquid medications are indicated as volume. The standard metric measurement for volume is the liter (le'ter). There are 1,000 milliliters (ml.) in a liter

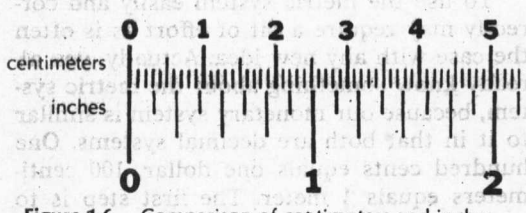

Figure 1.6. Comparison of centimeters and inches.

(l.). A liter is slightly greater than a quart, a liter being equal to 1.06 quarts. For smaller quantities the milliliter (ml.) is used most of the time. There are 5 ml. in a teaspoon and 15 ml. in a tablespoon. A fluid ounce contains 30 ml.

The Celsius (centigrade) temperature scale now in use by most other countries as well as by scientists in this country is discussed in Chapter 7, Body Temperature and Its Regulation.

Summary

1. **Living matter.**
   - A. Basic substance: protoplasm.
   - B. Structural unit: cell.
   - C. Principal parts of cell: cell membrane, cytoplasm, nucleus, nucleolus.
   - D. Organization of body cells: tissues, organs, systems.
2. **Body systems:** skeletal, muscular, circulatory, digestive, respiratory, integumentary, urinary, nervous (and sensory), endocrine, reproductive.
3. **Body directions.**
   - A. Superior, near head; inferior, away from head.
   - B. Ventral (anterior), near belly; dorsal (posterior), near back.
   - C. Cranial, near head; caudal, near end of spinal column.
   - D. Medial, near midsagittal plane; lateral, toward side.
   - E. Proximal, near origin; distal, distant from origin.
   - F. Body division by planes.
     - (1) Midsagittal: left and right portions.
     - (2) Frontal: front and rear portions.
     - (3) Transverse: top and bottom portions.
4. **Body cavities.**
   - A. Dorsal.
     - (1) Cranial.
     - (2) Spinal.
   - B. Ventral.
     - (1) Thoracic.
     - (2) Abdominal.
       - (a) 9 regions include epigastric, umbilical, hypogastric, right and left hypochondriac, right and left lumbar, and right and left iliac, or inguinal.
       - (b) 4 quadrants (no longer extensively used).
   - C. Dorsal cavities continuous, abdominal cavities separated by diaphragm.
5. **The metric system.**
   A logical decimal system.

Questions and Problems

1. Of what substance is living matter composed?
2. Define a cell. Name 4 main components of a typical cell.
3. Define: tissue, organ, body, system.
4. List the body systems, including a brief description of each with respect to its function.
5. List the opposite term for each of the following body functions: superior, ventral, anterior, cranial, medial, proximal. Define each item in the complete list.
6. What are the 3 main body planes? Explain the division of each.
7. Make a rough sketch of the 2 principal groups of body cavities, indicating the 9 divisions of the largest cavity.
8. Why should you learn the metric system? What are its advantages?